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Fertilization of Nitrogen, Phosphor and Application of Green Manure of *Crotalaria juncea* In Increasing Yield of Maize In Marginal Dry Land

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Abstract

This research aimed to analyze the effect of fertilization of N, P and application of green manure of crotalaria to increase yield of maize plant in marginal dry land. The experiment was carried out at the dry land of South Sulawesi Province, Indonesia from June to September 2013. This research was designed by using Split Plot Design. The main plot used green manures which consisted of two levels, i.e: without green manure and application of crotalaria green manure. The subplot was fertilization of N and P which consisted of three levels, without of fertilizer N and P; fertilization with a dose of 67.5 kg N.ha-1 + 33 kg P2O5.ha-1; 135 kg N ha-1 + 66 kg P2O5 ha-1. The results showed that fertilization of N, P and application of crotalaria green manure improved growth and increase the yield of maize. Fertilization with a dose of 135 kg N ha-1 + 66 kg P2O5 ha-1 with the application of Crotalaria obtained yield of maize as many as 7.234 tons ha-1 while fertilization at the same dose without the application of crotalaria obtained the yield as many as 6.172 tons ha-1.

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Keywords: Green manure, Crotalaria juncea, nitrogen, phosphor, and maize.

1. Introduction

Maize is a strategic commodity and of the second of the five commodities which becomes the main focus of agricultural development (DEPTAN, 2010). The increase of attention to maize plant is also followed by an increase in production and harvested of area from year to year, but the production per unit area is much lower than the

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potential of production that can be achieved. It can be seen from the average maize production that reaches 4.32 tons ha^{-1} (BPS, 2011), while the potential for maize production can reach 8-12 tons ha^{-1} (Syuryawati et al., 2000).

Various attempts have been made to increase the production of maize, such as through the intensification and extensification efforts, but because the extensification affort has shifted from the use of fertilized land into marginal lands. These are confronted with many obstacles, such as low soil fertility and low levels of organic matter soil (Samosir, 2000), thus providing adverse effects on growth and crop production. The low fertility of the soil can be overcome by inorganic fertilizer application. However, the use of inorganic fertilizers, such as fertilizers of N and P in solving the soil fertility problems, are often ineffective because of low soil buffering capacity resulting in nutrient easily leached out or fixed (Samosir, 1997), so that it is not available to plants. Therefore, we need a combination of the use of inorganic fertilizers with organic fertilizers (green manure) to improve the effectiveness of fertilizers applied.

Various types of organic fertilizers that can be used, such as manure, green manure and compost (Sutanto, 2002). The advantage of organic fertilizers is its ability to increase levels of organic matter of soil. Samosir (1997) discovered that organic matter is the key to soil fertility. Organic matter increase the ability of soil nutrient binding, thereby increasing the ability of the soil to provide nutrients to plants, reducing nutrient leaching, increasing the ability of soil to hold water, thus increasing soil water availability and soil structure stability as well as an energy source for soil biota (Samosir, 2000). The increased the water content of the soil with organic matter, would increase of maize plant resistance to drought (Subaedah et al., 2014)

Increasing the content of organic matter will improve the ability of soil to hold water and increase the nutrient content of the soil, including nitrogen, phosphate and micro elements which are mobilized and concentrated on the top layer of soil that can be utilized by the plants and therefore the integration of organic matter in the cultivation of maize in dry land experiencing abiotic stress expected to increase the availability of the resources needed by the plants that will increase the productivity of plants. Subaedah et al. (2004) discovered that the application of organic matter derived from forage crops (green manure) can increase total soil N levels up to 60%, up to 24% soil CEC and soil organic C by 25% compared without organic matter.

Although it is known that the use of wild plants can be used as a source of organic fertilizer (green manure), but it has not been fully utilized by farmers, especially wild plants Crotalaria. Therefore, this study was conducted to determine the effect of N and P fertilization and application of Crotalaria green manure in improving maize crop production in marginal dry land.

2. Material and Methods

The experiment was carried out at the dry land experimental station of BALITSEREAL, Gowa Regency, South Sulawesi Province, Indonesia from June to September 2013.

Planting materials consisted of maize seed of Lamuru Variety, green manure of *Crotalaria juncea* crop, urea, SP-36, KCl. Tools used included : the scales, labels, meters, ovens, SPAD chlorophyl meter and others.

The experiment consisted of two factors based on Split Plot Design with 3 replications. The main plot of crotalaria green manure treatments consisted of two levels i.e: without green manure (B0) and the use of crotalaria green manure as many as 10 tons ha^{-1}(B1). A subplot consisted of 3 levels i.e: without fertilization (P0), fertilization with a dose of 67.5 kg N ha^{-1} + 33 kg P_2O_5 ha^{-1} (P1) and fertilization with a dose of 135 kg N ha^{-1} + 66 kg P_2O_5 ha^{-1} (P2).

The experiment was conducted in the following ways: the land used in the experiment was divided into three blocks. Each block was divided into 2 main plots, then the main plot was divided into three subplots with 5 x 2.5 m. The planting of maize was done with a spacing of 70 cm x 25 cm. Urea and SP-36 was done in accordance with provision of treatment.

The weeding was done manually at the age of 20 and 40 days after planting maize. The parameters observed in this study included: plant biomass, leaf chlorophyl content, cob length, cob diameter, cob weight, and dry shelled production per ha.

3. Result and Discussion

The results of the analysis of maize plant biomass in Table 1 show that with fertilization at a dose of 67.5 kg N.ha^{-1} + 33 kg P2O5 ha^{-1}, the heaviest plant biomass is obtained and it is significantly different from treatment without fertilizer of N and P that just produces biomass plants with a weight of 67.70 g, but not significantly different from the dose of fertilizer 135 kg N.ha^{-1} + 66 kg P2O5 ha^{-1}.

Table 1. Fertilization of N, P and application of Crotalaria toward maize plant biomass (g) and Chlorophyll content (unit) at age 8 of WAP

Green Manure	Fertilization N and P			Average
	Without N & P	67.5 kg N+33 kg P_2O_5 ha^{-1}	135 kg N+ 66 kg P_2O_5 ha^{-1}	
		Plant Biomass (g)		
Without green manure	61.85	79.90	84.00	75.25
Green manure of Crotalaria	73.28	95.50	90.85	86.54
Average	67.57 b	87.70 a	87.42 a	
		Chlorophyll content (unit)		
Without green manure	33.43	50.82	48.58	44.27 b
Green manure of Crotalaria	45.32	45.32	53.26	49.78 a
Average	39.37 b	50.78 a	50.92	

Notes: Values followed by with the same letter at the same parameter are not significantly differen according to LSD (p=0.05)

The influence of both the growth of maize plants with fertilizer of N and P causes maize plant response to fertilizer of N. Fertilization of N can improve plant growth because N is an element required in the preparation of chlorophyl (Buckman et al., 1980). The chlorophyl content parameter which is also presented in Table 1 show that chlorophyl content increase with fertilizer of N and P with fertilization at a dose of 135 kg N ha^{-1} + 66 kg P2O5 ha^{-1}, the greatest chlorophyl content is obtained, i.e: 50.92 units and it is significantly different from chlorophyll content in plants that ise not given fertilizer of N and P only produces 39.37 units of chlorophyll. This is consistent with the results of research conducted by Herniwati & Tandisau (2010) reported that with fertilization of 200 kg urea ha^{-1} and 250 kg SP-36 ha^{-1}, the growth of the highest Sukmaraga maize varieties is obtained.

Chlorophyl content is also influenced by the application of green manure, with the application of crotalaria green manure, chlorophyll content is obtained as many as 49.78 units and it is significantly different from that contained chlorophyll content in maize which is not provided with the green manure that produces only 35 units of chlorophyll.

Good influence of application of green manure is due to the application of crotalaria green manure can increase nitrogen availability which further elements can be used by the maize in the preparation of chlorophyll. Chlorophyll is the cell organ that is holding the key role in photosynthesis, so that the increase in the formation of chlorophyll will improve photosynthetic activity and will ultimately improve plant growth and production.

Measurement results of cob length presented in Table 2 shows that the longest cob is 20.27 cm obtained in the treatment of fertilization of 135 kg N ha^{-1} + 66kg P2O5 ha^{-1} without the application of green manure (BOP2), but it is not significantly different from the length of the cob obtained in the application of green manure treatment with the same dose which produces the cob length of 18.30 cm, while the shortest cobs found in the interaction between no fertilizer of N and P with or without green manure (B0P0). In the cob diameter, it is parameter indicated in that the interaction between the application of green manure of crotalaria by fertilizing 135 kg N ha^{-1} + 66 kg P2O5 ha^{-1} (B1P2) the largest cob diameter obtained is 4.44 cm and significantly different from other interactions, except with the interaction between without green manure with the same dose of fertilizer that is 135 kg N ha^{-1} + 66kg P2O5 ha^{-1} (B0P2).

Table 2. Fertilization of N, P and application of green manure toward cob length and cob diameter maize

Treatment	Cob Length (cm)	Cob Diameter (cm)
B_0P_0	15. 40 cd	3.59 c
B_0P_1	16.47 bc	4.18 b
B_0P_2	20.27 a	4.31 a
B_1P_0	14.50 d	4.02 b
B_1P_1	17.90 b	4.16 b
B_1P_2	18.30 ab	4.44 a

Notes : Values followed by the same letter at the same column are not significantly different according to LSD (p=0.05)
B_0P_0 : Without green manure + 0 kg N + 0 kg P2O5,
B_0P_1: Without green manure + 67 .5 kg N ha^{-1} + 33 kg P_2O_5 ha^{-1}
B_0P_2 : Without green manure + 135 kg N ha^{-1} + 66 kg P_2O_5 ha^{-1}
B_1P_0 : Green manure + 0 kg N + 0 kg P2O5,
B_1P_1: Green manure + 67 .5 kg N ha^{-1} + 33 kg P_2O_5 ha^{-1}
B_1P_2 : Green manure + 135 kg N ha^{-1} + 66 kg P_2O_5 ha^{-1}

The interaction between the crotalaria green manure with fertilization of N and P is made possible by the ability of crotalaria in improving the content of organic matter of soil. The results show that the organic matter of soil increase with the application of green manure (data are not presented). The role of organic matter on the availability of nutrients in the soil can not be separated with the mineralization process as the final stage of the reform process of organic materials. In the process of mineralization, the mineral plants with a complete nutrient will be released, such as N, P, K, Ca, Mg and S and micro elements (Suntoro et al., 2001).

This is consistent with the results of research conducted by Sukartono et al. (2011) who report the increase in the levels of organic C, N, P, K, Ca and Mg as well as soil CEC with organic fertilizer application**.** The observation of cob weight shows that treatment of green manure of crotalaria and fertilization of N and P is also significant. The average weight of cobs in Table 3 shows that with the application of green manure, heavier cob is obtained namely 175.11 g and it is significantly different from without green manure with cob produced with 160.04 g. The fertilization of N and P shows that in fertilization with a dose of 135 kg N ha^{-1} + 66 kg P_2O_5 ha^{-1}, the heavier cob obtained is significantly different that is 222.70 g.

Table 3. Fertilization of N and P and applications of Crotalaria toward cob weight and production of dry shelled Maize (tons ha^{-1})

Green Manure	Fertilization N and P			Average
	Without N & P	67.5 kg N+33 kg P_2O_5 ha^{-1}	135 kg N+ 66 kg P_2O_5 ha^{-1}	
		Cob weight (g)		
Without green manure	104.20	167.07	208.77	160.01 b
Green manure of Crotalaria	113.78	174.93	236.67	175.11 a
Average	108.99 c	171.00 b	222.70 a	
		Productions of dry shelled (tons $ha^{-1)}$		
Without green manure	3.025	4.967	6.172	4.721 b
Green manure of Crotalaria	3.770	5.718	7.234	5.574 a
Average	3.398 b	5.343 a	6.703 a	

Notes: Values followed by with the same letter and the same parameter are not significantly different according to LSD (p=0.05)

Production of dry shelled maize per hectare presented in Table 3 shows that with the application of green manure, the heaviest dry shelled production obtained is 5.574 tons ha^{-1} and it is significantly different from without green

manure that only produces 4.721 tons ha^{-1}, so the fertilization treatment shows that with the fertilization of 135 kg N ha^{-1} + 66 kg P_2O_5 ha^{-1} the highest production of 6.703 tons ha^{-1} is obtained and it is significantly different from treatment without fertilizer of N and P that were only produces as many as 3.398 tons ha^{-1}.

Growth and crop production is highly dependent on the availability of nutrients. Nitrogen and phosphorus are macro nutrients needed by plants in large quantities (Gardner et al., 1985), while the availability of the two types of elements in the dry land is often an obstacle because N is leached, while the P element is fixed by other elements such as Al and Fe (Handayanto, 1998), so that N and P are elements that often limit plant growth. Therefore, the addition of N and P through fertilizer is needed, and the observations indicate that the higher dose of fertilizer of N and P gives the better growth and higher yield of maize.

Good effect of *Crotalaria juncea* green manure in improving production of maize is related to Crotalaria ability to decompose faster. Crotalaria containing N-total is quite high, i.e: 3.27%, the content of lignin and polyphenol is quite low, i.e: 7.42% and 0.78% (data from network analysis). This situation allows *Crotalaria juncea* to decompose faster and release nutrients that maize plants need faster and more results, so that growth and production of plants can take place better. According to Handayanto (1998) and Stevenson (1982) the speed of decomposition and mineralization is largely determined by the quality of the organic matter, the concentration of N, lignin and polyphenol concentrations. Besides, fertilizer of N is given will increase biological activity of soil, because the nitrogen content in the soil also affects biological activity of soil.

Thonnissen et al. (2000) stated that the release of nutrients from decomposition of organic matter is highly dependent on the quality and quantity of organic matter, soil moisture, temperature, biological activity of soil, and nutrient availability. Increasing the quantity of organic matter will improve the ability of soil to hold water and increase the nutrient content of the soil, including nitrogen, phosphate and micro elements that are mobilized and concentrated on the top layer of soil that can be utilized by plants. Thus, the ability of organic material from green manure of Crotalaria in improving the efficiency of fertilizer, especially N and P are the factors that determine the success of the growth that finally determines the outcomes obtained.

4. Conclusion

Fertilization of N, P and application of *Crotalatria juncea* green manure improve growth and increase the yield of maize in marginal dry land. Fertilization with doses of 135 kg N ha^{-1} + 66 kg P_2O_5 ha^{-1} and application of *Crotalaria juncea* green manure yield of maize obtained as many as 7.234 tons ha^{-1}, while in fertilizing at the same dose without application of crotalaria the yield of 6.172 tons ha^{-1} is obtained.

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